We claim:

1. A solid state membrane for use in a catalytic membrane reactor which comprises:

a mixed metal oxide having the stoichiometry:

$$A_{2-x}La_xB_{2-y}Fe_yO_{5+z}$$

wherein A is an alkaline earth metal ion or mixture of alkaline earth metal ions, B is a metal ion or mixture of metal ions where the metal is selected from the group consisting of the 3d transition metals, or the group 13 metals, x and y, independently of one another, are numbers equal to or greater than zero and less than 2, and z is a number that renders the compound neutral.

2. A solid state membrane for use in a catalytic membrane reactor which comprises:

a mixed metal oxide having the stoichiometry:

$$Sr_{2-x}La_xGa_{2-y}C_yO_{5+z}$$

where C is a 3d transition metal ion; x and y, independently of one another, are numbers equal to or greater than zero and less than 2, and z is a number that renders the compound neutral.

3. A solid state membrane for use in a catalytic membrane reactor which comprises:

a mixed metal oxide having the stoichiometry:

$Sr_{2-x}La_xGa_{2-y}Fe_yO_{5+z}$

wherein x and y, independently of one another, are numbers equal to or greater than zero and less than 2, and z is a number that renders the compound neutral.

4. The membrane of claim 1 further comprising a catalyst on the reduction or oxidation surfaces or on both the oxidation and reduction surfaces of the membrane.

5. The membrane of claim 4 comprising a catalyst on the oxidation surface of the membrane selected from the group consisting of Ni, Pd, Pt, Rh, Ir, Os, Fe, Mn, and Co, and alloys thereof, wherein these metals are incorporated as clusters into metal oxide ceramics selected from the group consisting of CeO_2, Bi_2O_3, ZrO_2, $CaB_{1-x}B'_xO_3$, $Sr_xB'_xO_3$, and $Ba_{1-x}B'_xO_3$, where B is Ce, Tb, or Pr, B' is a 3+ lanthanide ion and $0< x< 0.2$.

6. The membrane of claim 4 comprising a catalyst on the oxidation surface of the membrane having the composition $A_{1-x}A'_xB_{1-y}B'_yO_3$ where A is a lanthanide metal ion or a yttrium ion, A' is an alkali or an alkaline earth ion, B is a first row transition metal ion, B' is Ce, Cu, Ag, Au, Pt, Pd, or Ni, $0 < x < 0.8$ and $0 < y < 0.3$.

7. The membrane of claim 4 comprising a catalyst on the reduction surface of the membrane selected from the group consisting of Ag, $SrCo_{1-x}M_xO_3$ or $BaCo_{1-x}M_xO_3$, where M is Fe, Co or Ni and $0 < x < 0.5$.

8. The membrane of claim 4 for use in a catalytic membrane reactor for reduction of NO_x which comprises:

a reduction surface which in operation in said catalytic membrane reactor contacts NO_x and an oxidation surface which in operation in a catalytic membrane reactor contacts H_2, light hydrocarbons, CO or a partial vacuum, and

a catalyst on the oxidation surface of said membrane selected from the group consisting of Ag, Ni, $SrCo_{1-x}M_xO_3$ or $BaCo_{1-x}M_xO_3$, where M is Fe, Co or Ni and $0 < x < 0.5$.

9. The membrane of claim 4 for use in a catalytic membrane reactor for reduction of SO_x which comprises:

a reduction surface which in operation in said catalytic membrane reactor contacts SO_x and an oxidation surface which in operation in said catalytic membrane reactor contacts H_2, light hydrocarbons, CO or a partial vacuum;

a catalyst on the reduction surface of the membrane selected from the group consisting of ABS_3, where A is a lanthanide or yttrium ion, and B is Fe, Co, Ni,or Cu; AB_2S_4, where A is a 2+ first row transition metal ion and B is a 3+ first row transition metal ion; and Chevrel phases $A_2Mo_6S_8$, where A is Fe, Co, Ni, Cu, or Zn; and

a catalyst on the oxidation surface of the membrane selected from the group consisting of Ag, Ni, $SrCo_{1-x}M_xO_3$ or $BaCo_{1-x}M_xO_3$, where M is Fe, Co or Ni and $0 < x < 0.5$.

10. A membrane according to claim 4 which comprises:

a reduction surface in contact with oxygen, air or a gas mixture containing O_2 and an oxidation surface in contact with H_2S;

a catalyst on the oxidation surface of said membrane selected from the group consisting of AB_2S_4, where A is a 2+ Group VIII ion and B is a 3+ Group VIII ion; and WS_2; and

a catalyst on the reduction surface of said membrane selected from the group Ag, $SrCo_{1-x}M_xO_3$ or $BaCo_{1-x}M_xO_3$, where M is Fe, Co or Ni and $0 < x < 0.5$.

11. A membrane according to claim 4 for use in the catalytic separation of oxygen from a mixture with other gases which comprises:

an oxidation surface which in operation is in contact with a gas containing oxygen and a reduction surface in contact with an oxygen-depleted gas, inert gas or partial vacuum; and

a catalyst on the reduction surface of the membrane selected from the group consisting of Ag, $SrCo_{1-x}M_xO_3$ or $BaCo_{1-x}M_xO_3$, where M is Fe, Co or Ni and $0 < x < 0.5$.

12. A membrane according to claim 11 which comprises a catalyst on the oxidation surface of said membrane selected from the group consisting of

$AM_{1-x}M'_xO_3$, where A is Sr or Ba, M is Co or Ru and M' is Fe, Co, Ni or Ag and $0 < x < 0.5$;

$A_2M_2O_5$, where A is Ca or Sr and M is Fe or Mn;
$Pb_2Ru_2O_7$;

AB_2O_4, where A is a 2+ ion of Ni, Co, Fe, or Cu and B is a 3+ ion of Co, Fe, or Ni; and

$A_{1-x}A'_xMnO_3$, where A is a lanthanide metal ion or yttrium ion and A' is an alkaline earth metal ion.

13. The membrane of claim 3 which comprises a catalyst on the oxidation surface of the membrane wherein the catalyst is Ni supported on α-Al_2O_3.

14. The membrane of claim 4 which comprises a catalyst on the oxidation surface of the membrane wherein the catalyst is Ni supported on $La_{0.8}Sr_{0.2}MnO_{3-x}$.

15. A catalytic membrane reactor for reacting an oxygen-containing gas with a reactant gas which comprises:

a membrane as in claim 1;

a reactor cell having a reduction zone and an oxidation zone separated by said membrane;

a first entrance port for introduction of said oxygen-containing gas into said reduction zone;

a second entrance port for introduction of said reactant gas into said oxidation zone;

an exit port for gases exiting the reactor; and

a passage between said entrance ports and said exit port for movement of one or more gases through the reactor.

16. A catalytic membrane reactor for reacting an oxygen-containing gas with a reactant gas which comprises:

a reduction zone;

a plurality of reactor cells each having a membrane as in claim 1 and each having an oxidation zone separated from said reduction zone by said membrane;

a shell which contains the reactor cells;

an entrance port in said shell for introduction of said oxygen-containing gas into said reduction zone and an exit port in said shell for removal of reacted gas from said reduction zone; and

a means for introduction of said reactant gas into said oxidation zones and a means for removal of reacted gas from said oxidation zones;

said reactor cells positioned within the shell so that the shell, the reactor cells and the membranes of the reactor cells together form the reduction zone which is separated from the oxidation zones of said reactors by said membranes.

17. A catalytic membrane reactor for separating oxygen from an oxygen-containing gas which comprises a reactor cell having a reduction zone and an oxidation zone separated by a membrane as in claim 1.

18. A catalytic membrane reactor for separating oxygen from a mixture of gases containing oxygen which comprises:

a reduction zone;

a plurality of reactor cells each having a membrane as in claim 1 and each having an oxidation zone separated from said reduction zone by said membrane;

a shell which contains the reactor cells;

an entrance port in said shell for introduction of said mixture of gases containing oxygen into said reduction zone and an exit port in said shell for removal of reacted gas from said reduction zone; and

a means for removal of separated oxygen gas from said oxidation zones;

said reactor cells positioned within the shell so that the shell, the reactor cells and the membranes of the reactor cells together form the reduction zone which is separated from the oxidation zones of said reactors by said membranes.

19. The membrane of claim 1 wherein, in said mixed metal oxide, B is a mixture of Ga and Al.

20. The membrane of claim 1 wherein in said mixed metal oxide x is a number greater than 0 and less than or equal to about 1 and y is a number greater than 1 and less than or equal to 2.

21. The membrane of claim 1 wherein the B metal is selected from the group of Al, Ga, In and mixtures thereof.

22. The membrane of claim 21 wherein the B metal is Ga, Al or mixtures thereof.

23. The membrane of claim 21 wherein the B metal is Ga.

24. The membrane of claim 1 wherein the A metal is Sr, Ba, Ca or mixtures thereof.

25. The membrane of claim 24 wherein A is Sr, Ca or mixtures thereof.

26. The membrane of claim 24 wherein A is Sr.

27. The membrane of claim 1 wherein in the mixed metal oxide z is a number greater than zero and less than or equal to 0.4.

28. The membrane of claim 1 wherein in said mixed metal oxide z is a number greater than zero and less than or equal to 0.3.

29. The membrane of claim 1 wherein x is equal to zero.

30. The membrane of claim 1 wherein the A metal is Ca.

31. The membrane of claim 1 wherein the B metal is Al.